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Susanne Jakob
Dipl.-Ing. Helge Drumm

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V. Kocourek, J.-U. Mohring

Stability of free surfaces of liquid metals affected by a high-frequency magnetic field

In a first model experiment the dynamic behavior of liquid metal drops submitted to a high-frequency magnetic field is investigated. The motivation for this study comes from coating industry. Here it is favorable to evaporate liquid metals showing a free surface held in dome-type shape by an applied electromagnetic pressure. The drops are of Galinstan and are placed on a curved glass plate. A ring-like inductor fed by an alternating electrical current generates the magnetic field. The surface contour of the drop is observed using a high-speed camera system. The data are analyzed by utilizing image processing methods. In the first part we vary the inductor current I and the drop volume V while the frequency is fixed at 20 kHz. In the second part we vary the inductor current and the frequency of the magnetic field, the volume of the drop is fixed at 5 ml. Upon increasing the inductor current within the range $0 < I < I_C$, we first observe a static axisymmetric squeezing. However, when the inductor current exceeds a certain critical value, i.e. $I > I_C$, these symmetric states become unstable to capillary waves. The critical current as well as the critical mode number, the critical frequency and the amplitudes of the waves depend strongly on volume. The frequency of the magnetic field influences weakly the critical current and the critical mode number.
In a second model experiment we investigate the dynamics of a liquid metal surface confined in a thin annulus gap and affected by an electromagnetic pressure. In application, this experiment is a physical model for electromagnetic slit sealing during spin-casting processes. In the experiments we vary both geometry parameters as well as electromagnetic parameters. Again, when increasing the magnetic pressure by increasing the inductor current we observe three types of surface instabilities: (i) small-amplitude surface waves (ii) large-amplitude static surface deformations (iii) electromagnetic pinch.

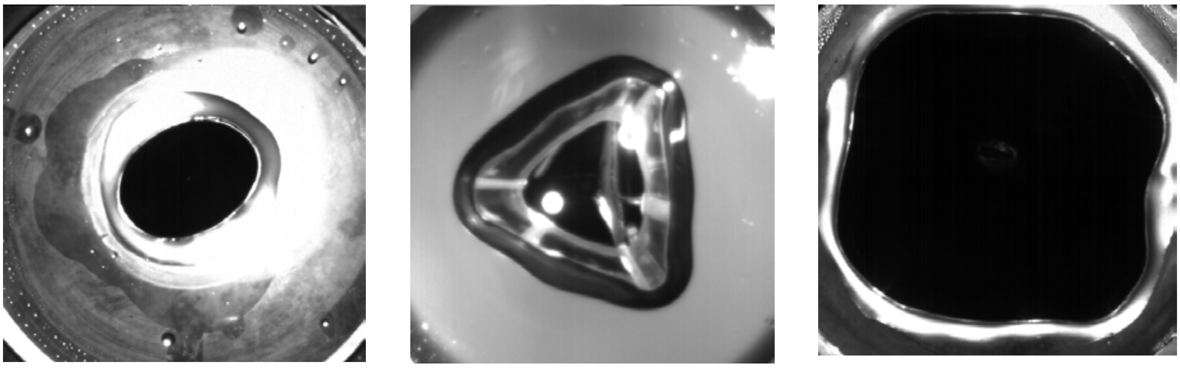

Fig.1. Surface instabilities observed in the first model experiment

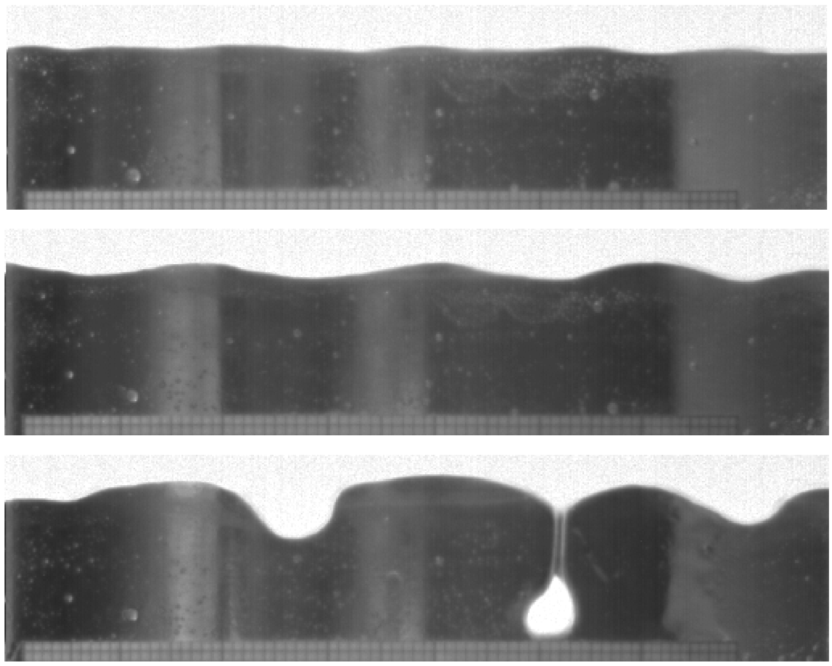

Fig.1. Surface instabilities observed in the second model experiment

(i) oscillating waves, (ii) standing waves, (iii) pinch

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Authors:

Vaclav Kocourek
Jens-Uwe Mohring
TU-Ilmenau, P.O.B. 100565
98684 Ilmenau
Phone:(03677)691509
Fax: (03677)691552
E-mail: Vaclav.Kocourek@tu-ilmenau.de